If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.
The on-screen version of the Collider-Accelerator Department Procedure is the Official Version.
Hard copies of all signed, official, C-A Operating Procedures are kept on file in the C-A ESHQ Training Office, Bldg. 911A.

C-A OPERATIONS PROCEDURES MANUAL

8.3.2 Operation of the RHIC Vacuum Systems Using Control System Consoles

Text Pages 2 through 12

Attachments

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: ***Signature on File***
Collider-Accelerator Department Chairman

Date

H. Hseuh

8.3.2 Operation of the RHIC Vacuum Systems Using Control System Consoles

1. Purpose and Scope

This procedure is for the monitoring and control of the RHIC vacuum systems using the RHIC control consoles and their application software. This procedure describes the layout, the instrumentation and the application software associated with the operation of the vacuum systems.

This procedure is to be used ***after*** the completion of assembly, pumpdown and leak checking of various vacuum sections.

2. Responsibility

Personnel within the Vacuum Section and other trained operations personnel are responsible to conduct the procedure.

3. Prerequisites

This procedure requires the use of control consoles or X-terminals located throughout the RHIC complex. Personnel involved in this procedure shall be familiar with the layout of the RHIC vacuum systems, the control consoles and their application software described Attachments 8.2 and 8.3.

4. Precautions

4.1 The vacuum gauges and ion pumps in the warm and cold beam vacuum sections are involved in the interlock of the rf-shielded gate valves. Turning off any vacuum gauges or pumps may trigger the closure of the gate valves. The ladder logic program in vacuum PLCs will remove the links to the Control Beam Permit chassis, which aborts the circulating beam(s).

4.2 The sputter ion pumps shall not be left on at pressure higher than 10^{-6} Torr for prolonged period. Repeated operation at high pressure will cause overheating and mechanical damage to the pump elements.

5. Procedures

This procedure requires the use of control consoles or X-terminals located throughout the RHIC complex. Personnel involved in this procedure shall be familiar with the layout of the vacuum systems, the control consoles and their application software described in Attachments 8.2 and 8.3.

5.1 Monitoring of Global Vacuum System Status Using 'RHIC Vacuum Display'

5.1.1 Start the console, if not already running, by following the procedure in Attachment 8.3.

5.1.2 Select 'Start' from the 'StartUp PPM User' page.

5.1.3 Select 'RHIC Applications'.

5.1.4 Select 'VacuumDisplay'.

Note:
The vacuum plots for both 'beam' and 'insulating' vacuums and for both 'yellow' and 'blue' rings shall appear. The plots have polar axes with perimeter corresponding to ring circumference. The radial axis is on a log scale and is inversely proportional to pressure. The summary status of the gate valves is also displayed outside the perimeter in the beam vacuum plot.

5.1.5 Choose 'beam, insulating or both', 'blue, yellow or both' and 'cold cathode, pirani or both' by using the option buttons on the right hand side to view the detail of each region.

Note:
The pirani type thermocouple gauges and the cold cathode gauges are abbreviated as TC and CC, respectively, in the site-wide naming system.

5.1.6 Use 'Setup' at the upper left corner to change the 'polling interval', 'axis scale' and print the display.

5.1.7 Use 'Data' at the upper left corner to view the numeric values of individual points on the plots and the status of individual valves.

Note:
The Pet program shall be used to review and remedy the cause(s) of high pressure and/or closed valve(s) after the exact location(s) of them are identified.

5.2 Monitoring of Individual Vacuum ADOs Using 'Pet'

5.2.1 Start the console, if not already running, by following the procedures in Attachment 8.3.

5.2.2 Start the 'Pet' page, if not already started, by following the procedures in Attachment 8.3.

5.2.3 Scroll down the Pet tree to select one of the nine vacuum branches.

5.2.4 Select the Pet page corresponding to the sector number of the vacuum ADOs of interest to view the readbacks and status of the ADOs.

5.3 Control of Individual Vacuum ADOs Using 'Pet'

The following procedure shall be used to turn on/off the high voltage of the cold cathode gauges and the ion pumps, and to open/close the gate valves. The pirani gauges do not require commands to operate. A separate OPM will be written for the operation of the cryostat turbomolecular pump stations.

Prior to turning on the HV of the cold cathode gauges and ion pumps, the pressure reading of the pirani gauge in the '**same**' vacuum section shall be verified to ensure that the pressure is indeed low enough. The names of the devices in the 'same' warm vacuum section or insulating vacuum section shall have the same **Sector#** and **Cell#**, (as explained in Attachment 8.2, 'Site Wide Names'). For example, check the pressure reading of yo4-tc-pw3.1 prior to operating yo4-cc-pw3.1 and yo4-ip-pw3.1.

5.3.1 Cold Cathode Gauges

5.3.1.1 Check the readbacks of the pirani gauge and the cold cathode gauges in the same vacuum section.

5.3.1.2 Turn off HV by selecting 'HV off' under 'Set HV' column if any cold cathode readings are higher than 10^{-3} Torr.

5.3.1.3 Turn on HV by selecting 'HV on' if the pirani reads 'LO E-3'.

5.3.1.4 Send a 'Reset' command to reset the gauge controller if 'RESET!!' is shown under 'Pressure' column in either cold cathode or pirani gauge pages.

5.3.2 Ring Ion Pumps

5.3.2.1 Check the readbacks of the ion pumps, the pirani gauge and the cold cathode gauges located in the same vacuum section.

5.3.2.2 Turn off HV by selecting 'HV off' under 'Set HV' column if ***either*** the pirani reading is higher than 10^{-3} Torr ***or*** pressure readings from cold cathodes or ion pumps are higher than 10^{-5} Torr.

5.3.2.3 Turn on HV by selecting 'HV on' if ***both*** the pirani reads 'LO E-3' ***and*** the cold cathode readings are lower than 10^{-5} Torr.

5.3.3 Rf-shielded GateValves

The set points of the gauges and pumps involved in the interlock of the gate valves must be satisfied before valves can be opened and remain open. The Pet pages in the 'VacuumInterlock' branch display the status of the valves as well as the set point status of the gauges and pumps on both sides of the valves and shall be used for diagnosis before operating the valves.

5.3.3.1 Check the status of the valve and the set point status of the gauges and pumps.

Warning:
The circulating beams will be dumped upon the closing of the valve(s).

5.3.3.2 Close the valve by selecting 'Close' under the command column.

5.3.3.3 Open the valve by selecting 'Open' under the command column if all the set points are satisfied.

5.3.3.4 Contact vacuum instrument specialists at x4612 if the valve(s) will not open while all the set points are satisfied.

5.4 Monitoring and Reset of the Vacuum PLCs

The vacuum PLCs have to be reset if 'Pet' is not updating the ADOs or not responding to the commands.

5.4.1 Start the console and the 'Pet' pages, if not already running by following the procedures in Attachment 8.3.

5.4.2 Select 'FEC', select 'Vacuum' then select 'PLC_check' to view the status of the PLC coprocessors. The time stamps of the active coprocessors shall reflect the real clock time.

5.4.3 Click the 'open/close' button of individual PLC coprocessor to send 'close' command. Wait for ~30 seconds, then send 'open' command to reset the PLC coprocessors.

5.5 Reboot of Vacuum FECs

The vacuum FECs have to be rebooted if Vacuum PLCs can't be reset.

5.5.1 Select 'diagnostics' in the 'Start' page.

5.5.2 Select 'Servers', then select 'RHIC FECs'.

5.5.3 Select one of the four vacuum FECs listed in Attachment 8.3.

5.5.4 Select 'fec diagnostics'.

5.5.5 Select 'Reboot'.

> **Note:**
> **The 'Reboot' of any one of the three-ring vacuum FECs will reboot all the three-ring vacuum FECs. It is necessary to reload Pet pages after 'Reboot'.**

6. Documentation

None

7. References

7.1 http://www.rhichome.bnl.gov/Controls/IndexADO.html

7.2 http://www.rhichome.bnl.gov/Controls/IndexVacuum.html

8. Attachments

8.1 Layout of RHIC Vacuum Systems.

8.2 Vacuum ADOs, Application Software and Site-Wide Names for Vacuum ADOs.

8.3 Operation Procedure of RHIC Vacuum Pet Pages.

Attachment 8.1

Layout of the RHIC Vacuum Systems

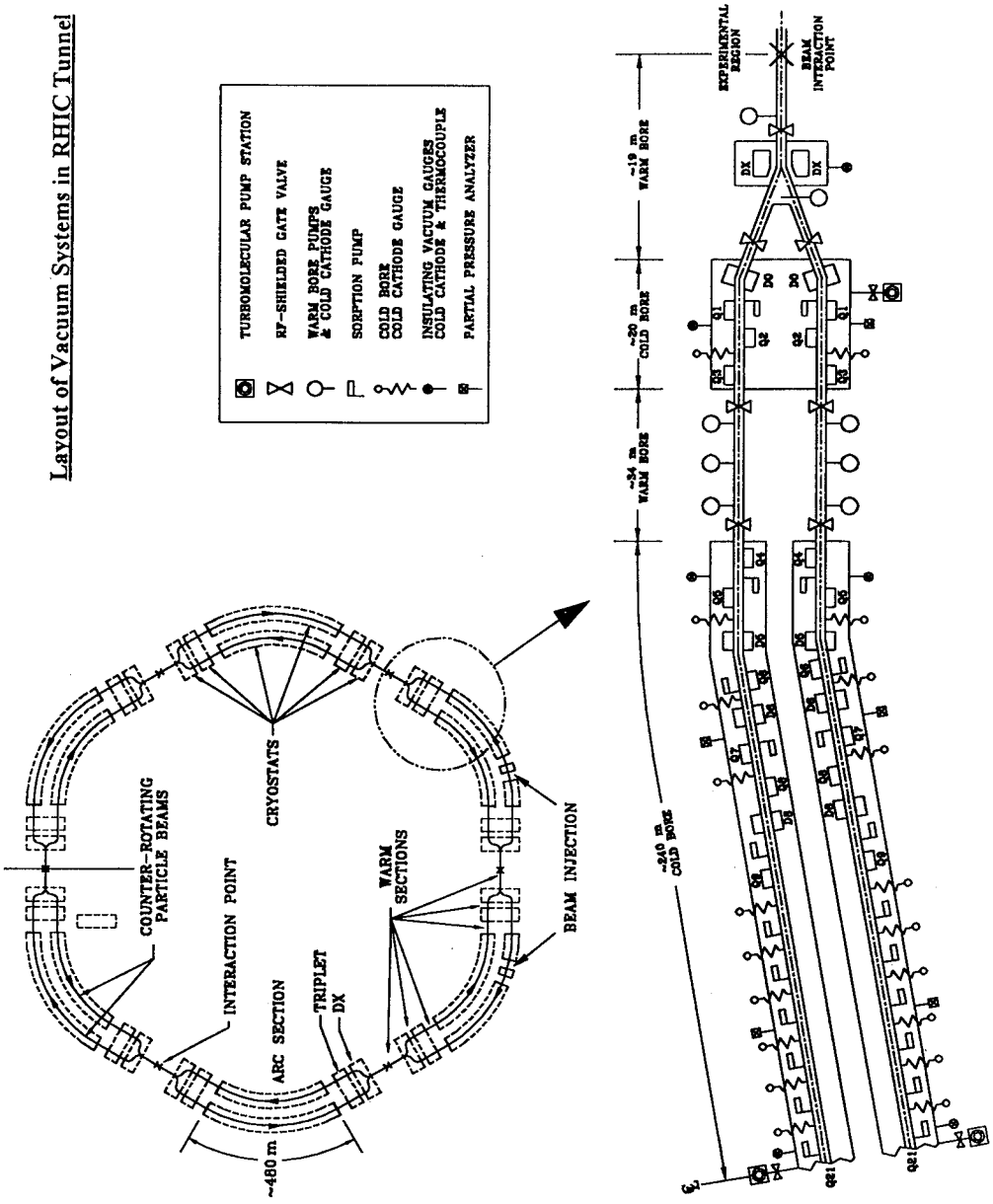
There are three distinct vacuum systems in RHIC; the warm beam vacuum system, the cold beam vacuum system and the insulating vacuum system. A schematic layout of the RHIC ring and the one-twelfth of the three vacuum systems are shown in the following figure.

There are 32 insulating vacuum volumes, 40 cold beam vacuum sections and 52 warm beam vacuum sections in two RHIC rings. The insulating vacuum volumes are separated from one another by welded physical barrier. The warm beam sections are isolatable from the adjacent warm or cold sections by rf-shielded gate valves.

Turbomolecular pump stations (TMP) are used to pump down and maintain the insulating vacuum. Twenty-four 'permanent' TMPs are located at arc Q21 interconnects and at triplet Q1 interconnects to maintain insulating vacuum before cooldown and to pump on helium leaks. A few 'mobile' TMPs are available for interconnects with high helium background.

Sputter ion pumps powered by 5 kV pump controllers are used to evacuate the warm sections to ultrahigh vacuum. Cold cathode gauges, pirani gauges and partial pressure analyzers are used to monitor pressure in all three vacuum systems. The pirani gauges read pressure from 760 Torr down to $1x10^{-3}$ Torr. The cold cathode gauges cover from $1x10^{-3}$ Torr to 10^{-11} Torr. The partial pressure analyzers are operable at pressures lower than 10^{-5} Torr. The sputter ion pumps are effective at pressures lower than 10^{-6} Torr.

The rf-shielded gate valves are controlled and interlocked for open/close by ladder logic programs in the vacuum PLCs using a voting scheme based on the set points of the gauges and ion pumps from either side of the gate valves. Any two pressure readings higher than the pre-determined set points will trigger the valve closure and prevent the reopening of the valves.


Layout of Vacuum Systems in RHIC Tunnel
TURBOMOLECULAR PUMP STATION
RF-SHIELDED GATE VALVE
WARM BORE PUMPS & COLD CATHODE GAUGE
SORPTION PUMP
COLD BORE COLD CATHODE GAUGE
INSULATING VACUUM GAUGES COLD CATHODE & THERMOCOUPLE
PARTIAL PRESSURE ANALYZER
CRYOSTATS
COUNTER-ROTATING PARTICLE BEAMS
INTERACTION POINT
ARC SECTION
TRIPLET DX
WARM SECTIONS
BEAM INJECTION
~480 m
EXPERIMENTAL REGION
BEAM INTERACTION POINT
~19 m WARM BORE
~20 m COLD BORE
~34 m WARM BORE
~240 m COLD BORE
DX
Q1
Q2
Q3
Q4
Q5
Q6
Q7

Attachment 8.2

Vacuum ADOs and Application Software

All the pumps, gate valves and most vacuum gauges are connected, through long cables, to their respective controllers, which are linked to the vacuum PLCs through RS485 serial network links. The PLCs interface with the vacuum FECs through Ethernet connection. The client server in the FECs configures each vacuum device with a unique ADO. The FECs gather data and send commands from and to the controllers through the PLCs. The FECs process the data and the commands for use by the console level application software. A typical list of vacuum ADOs with their site wide names are given below.

Two application softwares, '**RHIC Vacuum Display**' and '**Pet**', are available at Console level for the on-line monitoring and control of the vacuum ADOs.

'**RHIC Vacuum Display**' plots the vacuum distribution around the whole rings and gives the summary status of the beam vacuum gate valves located at every warm-to-cold interface and between some warm sections. There are warning and alarm levels in both beam and insulating vacuum readings. The exact location(s) of any vacuum readings exceeding the warning or alarm levels can be identified using the '**Data**' option in these plots. The exact location(s) of the closed gate valves can also be identified using the '**Data**' option.

'**Pet'** allows the monitoring and control of individual vacuum ADOs. There are a total of 1200 vacuum ADOs grouped into 9 Pet branches and 77 Pet pages according to the type of the vacuum devices and their locations. The parameters of ADOs vary from a single numerical readback for pirani gauges to a complicated operation sequence and multiple readbacks for turbopump stations and partial pressure analyzers.

Site Wide Names for RHIC Vacuum Devices

The general form of Site Wide Names for vacuum devices in the ring is:

Ring Sector# – Device – Port Cell #

Ring is 'y', 'b', or 'g' which stand for yellow ring, blue ring or interaction regions,
respectively.

Sector# ranges from 1 to 12

Device is abbreviated as follows:

sputter ion pump = ip
cold cathode gauge = cc
pirani type thermocouple gauge = tc
turbomolecular pump station = tmp
partial pressure analyzer = ppa
sector gate valve = sv

Port is a location within a half cell; the device is attached to the port.

cold bore port = pc
insulating vacuum port = pi
warm bore port = pw
accelerating cavity port = pra
storage cavity port = prs
port at beam dump = pwdmp
port at abort kicker = pwka
port at injection kicker = pwki
port at injection lambertson = pwlamb

Cell# is the location of the half cell in the 'Sector', generally the nearest quadrupole magnet.

Examples:

yo5-ip-pwlamb7.1	First ion pump on the injection lambertson located near Q7 of the sector 5 yellow ring (outer).
g5-tmp-pi1	Insulating vacuum turbomolecular pump located at Q1 cryostat of the sector 5 interaction region.

Attachment 8.3

Operation Procedure of RHIC Vacuum PET Pages

1. **Start the X-terminal Window:**
   Turn on the power switch of the terminal, wait for the bootup process to complete
   Type or select the server name (e.g. '***acnsun??.pbn.bnl.gov'***) and hit CR
   In the 'Welcome to acnsun??' page, enter your ***user name*** and hit CR
   Enter ***your password*** and hit CR
   The 'Solaris Welcome Page' will come up and followed by the '**StartUp** PPM user page

2. **Start Vacuum Pet Pages**
   At the '**Startup**' page, select "**start**' (use the '**up**' and '**down**' arrows to move through the console to reach the '**StartUp**' page or other pages).
   Select '**General Programs'**; Select '**pet**'
   Select '**RHIC**'; Select '**Vacuum**'

3. **Start Individual Vacuum Pet Pages (for status and control of vacuum devices)**
   Select one of the following nine types of the vacuum branches:
   SectorValves: AtR and RHIC beam vacuum sector valves
   CryostatGauges: cold cathode and Pirani gauges in insulating vacuum systems
   CryostatTMP: operation of insulating vacuum turbomolecular pump stations
   RingIonPumps: sputter ion pumps for yellow and blue ring warm beam vacuum systems
   VacuumInterlock: gauges and pumps interlocking the sector gate valves in beam vacuum
   YellowGauges: vacuum gauges in the yellow ring beam vacuum system
   BlueGauges: vacuum gauges in the blue ring beam vacuum system
   PPA: partial pressure analyzers for beam and insulating vacuum systems
   vjr Gauges: vacuum gauges for cryogenic valve box and transfer line insulation vacuum

   After choosing the desired **vacuum branch,** select the '**Sectors_?+??'** page (e.g. Sectors_11+12) corresponding to the desired vacuum sectors for status and control of individual vacuum ADOs

4. **Status of Vacuum FECs and PLCs**
   Select '**FECs**' instead of '**RHIC**' in procedure 2 to access the vacuum FECs and PLCs
   Select '**Vacuum**'
   Select '**PLC_check'** to view the status of the vauum FECs and PLC coprocessors:
   A list of the vacuum FECs and PLC coprocessors is listed below:

Note: **AtR Vacuum is located under 'AGS' then 'Vacuum_AtR'.**

FEC	PLC Coprocessor	Service Building#
cfe-6b-vac1	abc-2b-vac1, abc-2b-vac2	1002B
	abc-4b-vac1, abc-4b-vac2	1004B
cfe-6b-vac2	abc-6b-vac1, abc-6b-vac2	1006B
	abc-8b-vac1, abc-8b-vac2	1008A
cfe-6b-vac3	abc-10a-vac1, abc-10a-vac2	1010A
	abc-12a-vac1, abc-12a-vac2	1012A
cfe-wh-vac	abc-at-vac, abc-wh-vac	A-trailer & 1000P